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EXAMINER	
CHEN, QING	

ART UNIT	PAPER NUMBER
2191	

NOTIFICATION DATE	DELIVERY MODE
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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

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Office Action Summary	Application No.	Applicant(s)	
	10/676,557	LOWELL ET AL.	
	Examiner	Art Unit	
	Qing Chen	2191	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *21 January 2009*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-72* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-72* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *20090122*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. This Office action is in response to the amendment filed on January 21, 2009.

2. **Claims 1-72** are pending.

3. **Claims 1-4, 6, 8, 9, 15, 17-21, 23-25, 27-29, 31-34, 37-39, 48, 49, 52-54, 56-60, 62-64, 67, 69, and 71** have been amended.

4. The objection to the drawings is withdrawn in view of Applicant's amendments to the specification.

5. The objections to the specification are withdrawn in view of Applicant's amendments to the specification.

6. The objections to Claims 2-4, 6-11, 15, 18, 32-35, 37, 49-55, 57-60, and 63 are withdrawn in view of Applicant's amendments to the claims. However, Applicant's amendments to the claims fail to fully address the objection to Claim 19 due to improper antecedent basis. Accordingly, this objection is maintained and further explained hereinafter.

7. The provisional nonstatutory obviousness-type double patenting rejections of Claims 41 and 62 over copending Application No. 10/677,159 are held in abeyance until allowance of one of the copending applications.

8. The 35 U.S.C. § 112, second paragraph, rejections of Claims 8, 17, 34, 38, 39, 52-60, and 62-72 are withdrawn in view of Applicant's amendments to the claims.

9. The 35 U.S.C. § 101 rejections of Claims 1-72 are withdrawn in view of Applicant's amendments to the claims.

Information Disclosure Statement

10. The information disclosure statement filed on January 22, 2009 has been considered by the Examiner. All cited documents identified as "Non-Final Office Actions," "Final Office Actions," and "Notice of References Cited" are considered by the Examiner. However, these cited documents are official documents that are sent to Applicants in response to examination of patent applications and cannot be listed in a printed patent publication. An initial of the Examiner will cause these cited documents to be listed in the printed patent publication and therefore, a strikethrough of these cited documents is applied.

The cited documents considered by the Examiner but will not be listed in the printed patent publication are as follows (in no particular order):

- Final Office Action in U.S. Patent Application No. 10/677,159, U.S.P.T.O., pp. 1-17 (October 6, 2008).
- Non-Final Office Action in U.S. Patent Application No. 10/677,159, U.S.P.T.O., pp. 1-15 and Notice of References Cited (April 8, 2008).
- Non-Final Office Action in U.S. Patent Application No. 10/676,922, U.S.P.T.O., pp. 1-13 and Notice of References Cited (August 8, 2008).
- Final Office Action in U.S. Patent Application No. 10/676,922, U.S.P.T.O., pp. 1-11 (February 6, 2008).
- Non-Final Office Action in U.S. Patent Application No. 10/676,922, U.S.P.T.O., pp. 1-13 and Notice of References Cited (June 4, 2007).

Response to Amendment

Claim Objections

11. **Claims 19-30** are objected to because of the following informalities:

- **Claim 19** recites the limitation "the computer hardware." Applicant is advised to change this limitation to read "the virtualized computer hardware" for the purpose of providing it with proper explicit antecedent basis.

- **Claims 20-30** depend on Claim 19 and, therefore, suffer the same deficiency as Claim 19.

Appropriate correction is required.

Claim Rejections - 35 USC § 112

12. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

13. **Claims 52-60 and 62-72** are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claims 52 and 62 recite the limitation "a computer-readable storage medium containing software." The claim language fails to clearly point out the details relating to how software is "contained" on a computer-readable storage medium. Such an ambiguity further renders the claim scope indefinite for at least the reason that software can only be stored, recorded, or encoded on a computer-readable storage medium. In the interest of compact prosecution, the Examiner subsequently interprets this limitation as reading "a computer-readable storage medium storing software" for the purpose of further examination. Applicant is respectfully requested for further clarification of the claim language used.

Claims 53-60 depend on Claim 52 and, therefore, suffer the same deficiency as Claim 52.

Claims 63-72 depend on Claim 62 and, therefore, suffer the same deficiency as Claim 62.

Claim Rejections - 35 USC § 102

14. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

15. **Claims 19-21, 23, 25-30, 41-43, 45, 61-64, 66, and 70-72** are rejected under 35 U.S.C. 102(b) as being anticipated by **US 6,075,938 (hereinafter "Bugnion")**.

As per **Claim 19**, Bugnion discloses:

- devirtualizing the virtualized computer hardware at runtime of a computer containing the virtualized computer hardware *(see Column 9: 24-26, "Disco runs multiple independent virtual machines simultaneously on the same hardware by virtualizing all the resources of the machine."; Column 11: 8-20, "Disco contains a simple scheduler that allows the virtual processors to be time-shared across the physical processors of the machine." and "Disco will deschedule the virtual CPU until the mode is cleared or an interrupt is posted.").*

As per **Claim 20**, the rejection of **Claim 19** is incorporated; and Bugnion further discloses:

- wherein the virtualized computer hardware includes a CPU; and wherein the CPU is devirtualized at runtime *(see Column 9: 24-26, "Disco runs multiple independent virtual machines simultaneously on the same hardware by virtualizing all the resources of the machine."; Column 11: 8-20, "Disco contains a simple scheduler that allows the virtual processors to be time-shared across the physical processors of the machine." and "Disco will deschedule the virtual CPU until the mode is cleared or an interrupt is posted.").*

As per **Claim 21**, the rejection of **Claim 20** is incorporated; and Bugnion further discloses:

- wherein the virtualized computer hardware further includes physical memory, and the virtual machine monitor and the operating system each include CPU interrupt handlers; and wherein devirtualizing the CPU includes redirecting interrupts from the virtual machine monitor interrupt handlers to the corresponding operating system interrupt handlers *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ..."; Column 11: 31-34, "When a trap such as page fault, system call, or bus error occurs, the processor traps to the monitor that emulates the effect of the trap on the currently scheduled virtual processor. This is done by updating the privileged registers of the virtual processor and jumping to the virtual machine's trap vector.").*

As per **Claim 23**, the rejection of **Claim 21** is incorporated; and Bugnion further discloses:

- wherein devirtualizing the CPU further includes enabling physical memory access by the operating system *(see Column 13: 16-19, "... the memory management part of Disco must also deal with the allocation of real memory to virtual machines.")*.

As per **Claim 25**, the rejection of **Claim 19** is incorporated; and Bugnion further discloses:

- wherein the virtualized computer hardware includes memory; and wherein the memory is devirtualized at runtime *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ...")*.

As per **Claim 26**, the rejection of **Claim 25** is incorporated; and Bugnion further discloses:

- wherein memory was allocated from the operating system to the virtual machine monitor during virtualization of the memory; and wherein devirtualizing the memory includes returning the allocated memory to the operating system *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ...")*.

As per **Claim 27**, the rejection of **Claim 25** is incorporated; and Bugnion further discloses:

- wherein devirtualizing the memory includes remapping physical memory and using the operating system to manage address translation with respect to the devirtualized memory *(see Column 12: 6-15, "To virtualize physical memory, Disco adds a level of address translation and*

maintains physical-to-machine address mappings." and "Disco performs this physical-to-machine translation using the software-reloaded translation-lookaside buffer (TLB) of the MIPS processor.").

As per **Claim 28**, the rejection of **Claim 19** is incorporated; and Bugnion further discloses:

- wherein the virtualized computer hardware includes an I/O device, and wherein the I/O device is devirtualized at runtime *(see Column 9: 63-67 through Column 10: 1-13, "... requiring Disco to virtualize each I/O device." and "... these modifications can be made ... non-persistent so that they disappear with each reboot.").*

As per **Claim 29**, the rejection of **Claim 28** is incorporated; and Bugnion further discloses:

- wherein the operating system includes a dual-mode driver that performs direct hardware control in a first mode and communicates with a device driver of the virtual machine monitor in a second mode; and wherein devirtualizing the I/O device includes setting the dual-mode driver to the first mode; and redirecting I/O interrupts from handlers in the virtual machine monitor to handlers in the operating system *(see Column 11: 48-51, "Hardware interrupts are handled directly by the VMM through its own device drivers. The VMM posts an interrupt to the virtual machine when the operation that it has requested completes."; Column 14: 38-54, "We found it was much cleaner to simply add special device drivers into the operating system. Each Disco device defines a monitor call used by the device driver to pass all command arguments in*

a single trap." and "Disco's device drivers then interact directly with the physical device."; Column 17: 14-28, "Disco's monitor call interface reduces the complexity and overhead of accessing I/O devices." and "Fortunately, we designed the virtual machine monitor's internal device driver interface to simplify the integration of existing drivers written for commodity operating systems. Disco uses IRIX's original device drivers.").

As per **Claim 30**, the rejection of **Claim 28** is incorporated; and Bugnion further discloses:

- wherein devirtualizing the I/O device includes ceasing emulation of the I/O device at runtime *(see Column 10: 1-13, "... these modifications can be made ... non-persistent so that they disappear with each reboot.").*

As per **Claim 41**, Bugnion discloses:

- hardware, the hardware including memory, the memory encoded with means for virtualizing the hardware, and means for devirtualizing the hardware at runtime *(see Figure 1; Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ..."; Column 9: 24-26, "Disco runs multiple independent virtual machines simultaneously on the same hardware by virtualizing all the resources of the machine."; Column 11: 8-20, "Disco contains a simple scheduler that allows the virtual processors to be time-shared across the physical processors of the machine." and "Disco will deschedule the virtual CPU until the mode is cleared or an interrupt is posted.").*

As per **Claim 42**, the rejection of **Claim 41** is incorporated; and Bugnion further discloses:

- wherein the hardware further includes a CPU; and wherein the devirtualizing means devirtualizes the CPU at runtime *(see Column 9: 24-26, "Disco runs multiple independent virtual machines simultaneously on the same hardware by virtualizing all the resources of the machine."; Column 11: 8-20, "Disco contains a simple scheduler that allows the virtual processors to be time-shared across the physical processors of the machine." and "Disco will deschedule the virtual CPU until the mode is cleared or an interrupt is posted.").*

As per **Claim 43**, the rejection of **Claim 42** is incorporated; and Bugnion further discloses:

- wherein the memory is further encoded with an operating system including interrupt handlers; wherein the virtualizing means includes interrupt handlers; and wherein the devirtualizing means redirects interrupts from the interrupt handlers of the virtualizing means to the corresponding interrupt handlers of the operating system *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ..."; Column 11: 31-34, "When a trap such as page fault, system call, or bus error occurs, the processor traps to the monitor that emulates the effect of the trap on the currently scheduled virtual processor. This is done by updating the privileged registers of the virtual processor and jumping to the virtual machine's trap vector.").*

As per **Claim 45**, the rejection of **Claim 43** is incorporated; and Bugnion further discloses:

- wherein the devirtualizing means enables physical memory access by the operating system *(see Column 13: 16-19, "... the memory management part of Disco must also deal with the allocation of real memory to virtual machines.").*

As per **Claim 61**, Bugnion discloses:

- computer memory encoded with an I/O driver having first and second modes of operation, the I/O driver operable in the first mode to interface directly between the operating system and the I/O device, the I/O driver operable in the second mode to interface between the operating system and a corresponding I/O driver of the virtual machine monitor *(see Column 11: 48-51, "Hardware interrupts are handled directly by the VMM through its own device drivers. The VMM posts an interrupt to the virtual machine when the operation that it has requested completes."; Column 14: 38-54, "We found it was much cleaner to simply add special device drivers into the operating system. Each Disco device defines a monitor call used by the device driver to pass all command arguments in a single trap." and "Disco's device drivers then interact directly with the physical device."; Column 17: 14-28, "Disco's monitor call interface reduces the complexity and overhead of accessing I/O devices." and "Fortunately, we designed the virtual machine monitor's internal device driver interface to simplify the integration of existing drivers written for commodity operating systems. Disco uses IRIX's original device drivers.").*

As per **Claim 62**, Bugnion discloses:

- devirtualize at least a portion of virtualized hardware at runtime *(see Column 9: 24-26, "Disco runs multiple independent virtual machines simultaneously on the same hardware by virtualizing all the resources of the machine."; Column 11: 8-20, "Disco contains a simple scheduler that allows the virtual processors to be time-shared across the physical processors of the machine." and "Disco will deschedule the virtual CPU until the mode is cleared or an interrupt is posted.").*

As per **Claim 63**, the rejection of **Claim 62** is incorporated; and Bugnion further discloses:

- wherein the computer hardware further includes a CPU; and wherein the software causes the CPU to be devirtualized at runtime *(see Column 9: 24-26, "Disco runs multiple independent virtual machines simultaneously on the same hardware by virtualizing all the resources of the machine."; Column 11: 8-20, "Disco contains a simple scheduler that allows the virtual processors to be time-shared across the physical processors of the machine." and "Disco will deschedule the virtual CPU until the mode is cleared or an interrupt is posted.").*

As per **Claim 64**, the rejection of **Claim 63** is incorporated; and Bugnion further discloses:

- wherein the virtualized hardware further includes memory, and wherein a memory is further encoded with an operating system including first interrupt handlers; wherein the software includes second interrupt handlers; and wherein the software causes interrupts to be redirected

from the second interrupt handlers to the corresponding first interrupt handlers *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ..."; Column 11: 31-34, "When a trap such as page fault, system call, or bus error occurs, the processor traps to the monitor that emulates the effect of the trap on the currently scheduled virtual processor. This is done by updating the privileged registers of the virtual processor and jumping to the virtual machine's trap vector.").*

As per **Claim 66**, the rejection of **Claim 64** is incorporated; and Bugnion further discloses:

- wherein the software causes physical memory access by the operating system to be enabled *(see Column 13: 16-19, "... the memory management part of Disco must also deal with the allocation of real memory to virtual machines.").*

As per **Claim 70**, the rejection of **Claim 62** is incorporated; and Bugnion further discloses:

- wherein the virtualized hardware includes an I/O device; and wherein the software causes the I/O device to be devirtualized at runtime *(see Column 9: 63-67 through Column 10: 1-13, "... requiring Disco to virtualize each I/O device." and "... these modifications can be made ... non-persistent so that they disappear with each reboot.").*

As per **Claim 71**, the rejection of **Claim 70** is incorporated; and Bugnion further discloses:

- wherein the virtualized hardware further includes a memory, and wherein the memory is further encoded with an operating system including dual-mode drivers that perform direct hardware control in a first mode and communicate with virtual device drivers in a second mode; and wherein the software causes the dual-mode drivers to be set to the first mode *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ..."; Column 11: 48-51, "Hardware interrupts are handled directly by the VMM through its own device drivers. The VMM posts an interrupt to the virtual machine when the operation that it has requested completes."; Column 14: 38-54, "We found it was much cleaner to simply add special device drivers into the operating system. Each Disco device defines a monitor call used by the device driver to pass all command arguments in a single trap." and "Disco's device drivers then interact directly with the physical device."; Column 17: 14-28, "Disco's monitor call interface reduces the complexity and overhead of accessing I/O devices." and "Fortunately, we designed the virtual machine monitor's internal device driver interface to simplify the integration of existing drivers written for commodity operating systems. Disco uses IRIX's original device drivers.").*

As per **Claim 72**, the rejection of **Claim 70** is incorporated; and Bugnion further discloses:

- wherein the software causes emulation of the I/O device to cease at runtime *(see Column 10: 1-13, "... these modifications can be made ... non-persistent so that they disappear with each reboot.").*

Claim Rejections - 35 USC § 103

16. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

17. **Claims 1-18, 31-40, and 52-60** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Bugnion** in view of **US 6,961,941 (hereinafter "Nelson")**.

As per **Claim 1**, Bugnion discloses:

- interposing the virtual machine monitor between the computer hardware and the operating system at runtime *(see Figure 1; Column 2: 36-40, "Virtual machine monitors (VMMs) implement in software a virtual machine identical to the underlying hardware. IBM's VM/370 (IBM, 1972) system, for example, allows the simultaneous execution of independent operating systems by virtualizing all the hardware resources."; Column 9: 24-26, "Disco runs multiple independent virtual machines simultaneously on the same hardware by virtualizing all the resources of the machine.").*

However, Bugnion does not disclose:

- wherein the interposing occurs after booting of the computer.

Nelson discloses:

- wherein the interposing occurs after booting of the computer *(see Abstract, "After booting, the kernel is loaded ..." and "In the preferred embodiment of the invention, at least one*

virtual machine (VM) runs via a virtual machine monitor, which is installed to run on the kernel.").

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of Nelson into the teaching of Bugnion to include wherein the interposing occurs after booting of the computer. The modification would be obvious because one of ordinary skill in the art would be motivated to mitigate the complication of management and governing of CPU, memory and I/O resources by the virtual machine monitor *(see Nelson – Column 2: 9-11).*

As per **Claim 2,** the rejection of **Claim 1** is incorporated; however, Bugnion does not disclose:

- booting the operating system on the computer hardware before interposing the virtual machine monitor at runtime.

Nelson discloses:

- booting the operating system on the computer hardware before interposing the virtual machine monitor at runtime *(see Column 18: 10-12,, "1) Booting the machine. As is mentioned above, the COS brings up the machine in uniprocessor mode. Once the machine is booted, the kernel 600 can be loaded.").*

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of Nelson into the teaching of Bugnion to include booting the operating system on the computer hardware before interposing the virtual

machine monitor at runtime. The modification would be obvious because one of ordinary skill in the art would be motivated to run the operating system.

As per **Claim 3**, the rejection of **Claim 1** is incorporated; and Bugnion further discloses:

- devirtualizing the computer hardware before interposing the virtual machine monitor at runtime *(see Figure 1; Column 9: 24-26, "Disco runs multiple independent virtual machines simultaneously on the same hardware by virtualizing all the resources of the machine.").*

However, Bugnion does not disclose:

- booting the virtual machine monitor on the computer hardware and booting the operating system on the virtual machine monitor.

Nelson discloses:

- booting the virtual machine monitor on the computer hardware and booting the operating system on the virtual machine monitor *(see Abstract, "After booting, the kernel is loaded ..." and "In the preferred embodiment of the invention, at least one virtual machine (VM) runs via a virtual machine monitor, which is installed to run on the kernel."; Column 2: 1-3, "In some conventional systems, the VMM runs directly on the underlying hardware, and will thus act as the "host" operating system for its associated VM.").*

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of Nelson into the teaching of Bugnion to include booting the virtual machine monitor on the computer hardware and booting the operating system on the virtual machine monitor. The modification would be obvious because one of ordinary skill in the art would be motivated to run the operating system.

As per **Claim 4**, the rejection of **Claim 1** is incorporated; and Bugnion further discloses:

- devirtualizing the computer hardware after the virtual machine monitor has been interposed *(see Column 9: 24-26, "Disco runs multiple independent virtual machines simultaneously on the same hardware by virtualizing all the resources of the machine."; Column 11: 8-20, "Disco contains a simple scheduler that allows the virtual processors to be time-shared across the physical processors of the machine." and "Disco will deschedule the virtual CPU until the mode is cleared or an interrupt is posted.").*

As per **Claim 5**, the rejection of **Claim 1** is incorporated; and Bugnion further discloses:

- wherein the computer hardware includes a CPU; and wherein the virtual machine monitor is interposed on the CPU *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ...").*

As per **Claim 6**, the rejection of **Claim 5** is incorporated; and Bugnion further discloses:

- wherein the computer hardware further includes memory, and the virtual machine monitor and the operating system each include CPU interrupt handlers; and wherein interposing the virtual machine monitor on the CPU includes causing privileged instructions to trap to the virtual machine monitor, and redirecting interrupts from the operating system interrupt handlers to the corresponding virtual machine monitor interrupt handlers *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ..."; Column 11: 31-34, "When a trap such as page fault, system call, or bus error occurs, the processor traps*

to the monitor that emulates the effect of the trap on the currently scheduled virtual processor. This is done by updating the privileged registers of the virtual processor and jumping to the virtual machine's trap vector.").

As per **Claim 7**, the rejection of **Claim 6** is incorporated; and Bugnion further discloses:

- wherein the privileged instructions are caused to trap to the virtual machine monitor by causing the operating system to run at a reduced privilege level; and wherein interposing the virtual machine monitor on the CPU further includes returning control to the operating system at the reduced privilege level *(see Column 11: 25-28, "Supervisor mode allows the operating system to use a protected portion of the address space (the supervisor segment) but does not give access to privileged instructions or physical memory.").*

As per **Claim 8**, the rejection of **Claim 6** is incorporated; and Bugnion further discloses:

- wherein the privileged instructions are caused to trap to the virtual machine monitor by using a kernel module of the operating system to reduce a privilege level of the operating system *(see Column 11: 37-41, "Disco maintains all the privileged registers in the VCPU structure. Privileged instructions that change the state of privileged registers are emulated by the monitor.").*

As per **Claim 9**, the rejection of **Claim 6** is incorporated; and Bugnion further discloses:

- wherein interposing the virtual machine monitor on the CPU further includes disabling physical memory access by the operating system *(see Column 3: 39-41, "By running*

the OS in supervisor mode, it disables direct access to I/O resources and physical memory, without having to virtualize them.").

As per **Claim 10**, the rejection of **Claim 6** is incorporated; and Bugnion further discloses:

- wherein the computer hardware includes memory; and wherein interposing the virtual machine monitor on the CPU further includes loading the virtual machine monitor into the memory *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ...").*

As per **Claim 11**, the rejection of **Claim 10** is incorporated; and Bugnion further discloses:

- wherein a kernel module of the operating system is used to allocate memory within the operating system, pin the allocated memory, and load the virtual machine monitor into the pinned memory *(see Column 10: 37-40, "... the small code segment of Disco, currently 72KB, is replicated into all the memories of FLASH machine so that all instruction cache misses can be satisfied from the local node.").*

As per **Claim 12**, the rejection of **Claim 5** is incorporated; and Bugnion further discloses:

- wherein the computer hardware includes memory; and wherein the virtual machine monitor is also interposed on the memory *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ...").*

As per **Claim 13**, the rejection of **Claim 12** is incorporated; and Bugnion further discloses:

- wherein interposing the virtual machine monitor on the memory includes partitioning the memory, and giving the virtual machine monitor access to at least one of the partitions *(see Column 2: 42-44, "VM/370 maps virtual disks to distinct volumes (partitions) ...").*

As per **Claim 14**, the rejection of **Claim 12** is incorporated; and Bugnion further discloses:

- wherein interposing the virtual machine monitor on the memory includes using a kernel module of the operating system to allocate a block of the memory, pin the block to prevent the operating system from using the block, and allocate the pinned block to the virtual machine monitor *(see Column 10: 37-40, "... the small code segment of Disco, currently 72KB, is replicated into all the memories of FLASH machine so that all instruction cache misses can be satisfied from the local node.").*

As per **Claim 15**, the rejection of **Claim 12** is incorporated; and Bugnion further discloses:

- wherein interposing the virtual machine monitor on the memory includes commencing using the virtual machine monitor at runtime to manage memory translation *(see Column 12: 6-15, "To virtualize physical memory, Disco adds a level of address translation and maintains physical-to-machine address mappings." and "Disco performs this physical-to-*

machine translation using the software-reloaded translation-lookaside buffer (TLB) of the MIPS processor.").

As per **Claim 16**, the rejection of **Claim 5** is incorporated; and Bugnion further discloses:

- wherein the computer hardware includes an I/O device, and wherein the virtual machine monitor is also interposed on the I/O device *(see Column 9: 63-67 through Column 10: 1-2, "... requiring Disco to virtualize each I/O device."; Column 14: 32-34, "To virtualize access to I/O devices, Disco intercepts all device accesses from the virtual machine and forwards them to the physical devices.").*

As per **Claim 17**, the rejection of **Claim 16** is incorporated; and Bugnion further discloses:

- wherein the operating system includes a dual-mode driver that performs direct hardware control in a first mode and communicates with a device driver of the virtual machine monitor in a second mode; and wherein interposing the virtual machine monitor on the I/O device includes setting the dual-mode driver to the second mode; and redirecting I/O interrupts from interrupt handlers in the operating system to interrupt handlers in the virtual machine monitor *(see Column 11: 48-51, "Hardware interrupts are handled directly by the VMM through its own device drivers. The VMM posts an interrupt to the virtual machine when the operation that it has requested completes."; Column 14: 38-54, "We found it was much cleaner to simply add special device drivers into the operating system. Each Disco device defines a monitor call used by the device driver to pass all command arguments in a single trap." and "Disco's device*

drivers then interact directly with the physical device."; Column 17: 14-28, "Disco's monitor call interface reduces the complexity and overhead of accessing I/O devices." and "Fortunately, we designed the virtual machine monitor's internal device driver interface to simplify the integration of existing drivers written for commodity operating systems. Disco uses IRIX's original device drivers.").

As per **Claim 18**, the rejection of **Claim 16** is incorporated; and Bugnion further discloses:

- wherein interposing the virtual machine monitor on the I/O device includes commencing I/O emulation of the I/O device at runtime *(see Column 9: 63-67 through Column 10: 1-2, "Disco must intercept all communication to and from I/O devices to translate or emulate the operation.").*

As per **Claim 31**, Bugnion discloses:

- hardware, the hardware including memory, the memory encoded with an operating system, a virtual machine monitor, and means for interposing the virtual machine monitor on the hardware at runtime *(see Figure 1; Column 2: 36-40, "Virtual machine monitors (VMMs) implement in software a virtual machine identical to the underlying hardware. IBM's VM/370 (IBM, 1972) system, for example, allows the simultaneous execution of independent operating systems by virtualizing all the hardware resources."; Column 9: 24-26, "Disco runs multiple independent virtual machines simultaneously on the same hardware by virtualizing all the resources of the machine.").*

However, Bugnion does not disclose:

- wherein the interposing occurs after booting of the computer.

Nelson discloses:

- wherein the interposing occurs after booting of the computer *(see Abstract, "After booting, the kernel is loaded ..." and "In the preferred embodiment of the invention, at least one virtual machine (VM) runs via a virtual machine monitor, which is installed to run on the kernel.").*

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of Nelson into the teaching of Bugnion to include wherein the interposing occurs after booting of the computer. The modification would be obvious because one of ordinary skill in the art would be motivated to mitigate the complication of management and governing of CPU, memory and I/O resources by the virtual machine monitor *(see Nelson – Column 2: 9-11).*

As per **Claim 32**, the rejection of **Claim 31** is incorporated; and Bugnion further discloses:

- wherein the hardware further includes a CPU, and the virtual machine monitor and the operating system each include CPU interrupt handlers; and wherein the interposing means causes privileged instructions to trap to the virtual machine monitor, and redirects interrupts and traps from the operating system interrupt handlers to the corresponding virtual machine monitor interrupt handlers, whereby the virtual machine monitor is interposed on the CPU at runtime *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and*

memory) ..."; Column 11: 31-34, "When a trap such as page fault, system call, or bus error occurs, the processor traps to the monitor that emulates the effect of the trap on the currently scheduled virtual processor. This is done by updating the privileged registers of the virtual processor and jumping to the virtual machine's trap vector.").

As per **Claim 33**, the rejection of **Claim 32** is incorporated; and Bugnion further discloses:

- wherein the interposing means causes privileged instructions to trap to the virtual machine monitor by causing the operating system to run at a reduced privilege level; and wherein the interposing means reduces a privilege level of the operating system after redirecting the interrupts, and returns control to the operating system at the reduced privilege level *(see Column 11: 25-28, "Supervisor mode allows the operating system to use a protected portion of the address space (the supervisor segment) but does not give access to privileged instructions or physical memory.").*

As per **Claim 34**, the rejection of **Claim 32** is incorporated; and Bugnion further discloses:

- wherein the interposing means includes a kernel module of the operating system for reducing a privilege level of the operating system, whereby the privileged instructions trap to the virtual machine monitor *(see Column 11: 37-41, "Disco maintains all the privileged registers in the VCPU structure. Privileged instructions that change the state of privileged registers are emulated by the monitor.").*

As per **Claim 35**, the rejection of **Claim 32** is incorporated; and Bugnion further discloses:

- wherein the interposing means disables physical memory access by the operating system *(see Column 3: 39-41, "By running the OS in supervisor mode, it disables direct access to I/O resources and physical memory, without having to virtualize them.").*

As per **Claim 36**, the rejection of **Claim 31** is incorporated; and Bugnion further discloses:

- wherein the interposing means includes a kernel module of the operating system for allocating a block of the memory, pinning the block to prevent the operating system from using the block, and allocating the pinned block to the virtual machine monitor, whereby the virtual machine monitor is interposed on the memory at runtime *(see Column 10: 37-40, "... the small code segment of Disco, currently 72KB, is replicated into all the memories of FLASH machine so that all instruction cache misses can be satisfied from the local node.").*

As per **Claim 37**, the rejection of **Claim 31** is incorporated; and Bugnion further discloses:

- wherein the interposing means commences using the virtual machine monitor at runtime to manage memory translation, whereby the virtual machine monitor is interposed on the memory at runtime *(see Column 12: 6-15, "To virtualize physical memory, Disco adds a level of address translation and maintains physical-to-machine address mappings." and "Disco*

performs this physical-to-machine translation using the software-reloaded translation-lookaside buffer (TLB) of the MIPS processor.").

As per **Claim 38**, the rejection of **Claim 31** is incorporated; and Bugnion further discloses:

- wherein the hardware further includes an I/O device; and wherein the interposing means includes an operating system dual-mode driver that performs direct hardware control in a first mode and communicates with a device driver of the virtual machine monitor in a second mode; and wherein the interposing means sets the dual-mode driver to the second mode; and redirects I/O interrupts from interrupt handlers in the operating system to interrupt handlers in the virtual machine monitor, whereby the virtual machine monitor is interposed on the I/O device at runtime *(see Column 11: 48-51, "Hardware interrupts are handled directly by the VMM through its own device drivers. The VMM posts an interrupt to the virtual machine when the operation that it has requested completes."; Column 14: 38-54, "We found it was much cleaner to simply add special device drivers into the operating system. Each Disco device defines a monitor call used by the device driver to pass all command arguments in a single trap." and "Disco's device drivers then interact directly with the physical device."; Column 17: 14-28, "Disco's monitor call interface reduces the complexity and overhead of accessing I/O devices." and "Fortunately, we designed the virtual machine monitor's internal device driver interface to simplify the integration of existing drivers written for commodity operating systems. Disco uses IRIX's original device drivers.").*

As per **Claim 39**, the rejection of **Claim 31** is incorporated; and Bugnion further discloses:

- wherein the hardware further includes an I/O device; and wherein the operating system includes a dual-mode driver that performs direct hardware control in a first mode and communicates with a device driver of the virtual machine monitor in a second mode; and wherein the interposing means sets the dual-mode driver to the second mode; and redirects I/O interrupts from interrupt handlers in the operating system to interrupt handlers in the virtual machine monitor, whereby the virtual machine monitor is interposed on the I/O device *(see Column 11: 48-51, "Hardware interrupts are handled directly by the VMM through its own device drivers. The VMM posts an interrupt to the virtual machine when the operation that it has requested completes."; Column 14: 38-54, "We found it was much cleaner to simply add special device drivers into the operating system. Each Disco device defines a monitor call used by the device driver to pass all command arguments in a single trap." and "Disco's device drivers then interact directly with the physical device."; Column 17: 14-28, "Disco's monitor call interface reduces the complexity and overhead of accessing I/O devices." and "Fortunately, we designed the virtual machine monitor's internal device driver interface to simplify the integration of existing drivers written for commodity operating systems. Disco uses IRIX's original device drivers.")*.

As per **Claim 40**, the rejection of **Claim 31** is incorporated; and Bugnion further discloses:

- wherein the hardware further includes an I/O device; and wherein the interposing means commences I/O emulation of the I/O device at runtime, whereby the virtual machine monitor is interposed on the I/O device at runtime *(see Column 9: 63-67 through Column 10: 1-2, "Disco must intercept all communication to and from I/O devices to translate or emulate the operation.")*.

As per **Claim 52**, Bugnion discloses:

- virtualize at least a portion of the computer hardware at runtime *(see Figure 1; Column 2: 36-40, "Virtual machine monitors (VMMs) implement in software a virtual machine identical to the underlying hardware. IBM's VM/370 (IBM, 1972) system, for example, allows the simultaneous execution of independent operating systems by virtualizing all the hardware resources."; Column 9: 24-26, "Disco runs multiple independent virtual machines simultaneously on the same hardware by virtualizing all the resources of the machine.")*.

However, Bugnion does not disclose:

- wherein the virtualizing occurs after boot of the computer and loading of the operating system.

Nelson discloses:

- wherein the virtualizing occurs after boot of the computer and loading of the operating system *(see Abstract, "After booting, the kernel is loaded ..." and "In the preferred embodiment of the invention, at least one virtual machine (VM) runs via a virtual machine monitor, which is installed to run on the kernel.")*.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of Nelson into the teaching of Bugnion to include wherein the virtualizing occurs after boot of the computer and loading of the operating system. The modification would be obvious because one of ordinary skill in the art would be motivated to mitigate the complication of management and governing of CPU, memory and I/O resources by the virtual machine monitor *(see Nelson – Column 2: 9-11)*.

As per **Claim 53**, the rejection of **Claim 52** is incorporated; and Bugnion further discloses:

- wherein the computer hardware further includes a CPU, and wherein the computer hardware is virtualized using a virtual machine monitor, and the virtual machine monitor and the operating system each include CPU interrupt handlers; and wherein the software causes privileged instructions to trap to the virtual machine monitor, and causes interrupts and traps to be redirected from the operating system interrupt handlers to the corresponding virtual machine monitor interrupt handlers *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ..."; Column 11: 31-34, "When a trap such as page fault, system call, or bus error occurs, the processor traps to the monitor that emulates the effect of the trap on the currently scheduled virtual processor. This is done by updating the privileged registers of the virtual processor and jumping to the virtual machine's trap vector.")*.

As per **Claim 54**, the rejection of **Claim 53** is incorporated; and Bugnion further discloses:

- wherein the software causes the privileged instructions to trap to the virtual machine monitor by reducing a privilege level of the operating system, and wherein the software causes control to be returned to the operating system at the reduced privilege level *(see Column 11: 25-28, "Supervisor mode allows the operating system to use a protected portion of the address space (the supervisor segment) but does not give access to privileged instructions or physical memory.").*

As per **Claim 55**, the rejection of **Claim 53** is incorporated; and Bugnion further discloses:

- wherein the software causes physical memory access by the operating system to be disabled *(see Column 3: 39-41, "By running the OS in supervisor mode, it disables direct access to I/O resources and physical memory, without having to virtualize them.").*

As per **Claim 56**, the rejection of **Claim 52** is incorporated; and Bugnion further discloses:

- wherein the hardware includes memory, and wherein the software includes a virtual machine monitor for causing a kernel module of the operating system to allocate a block of a memory, pin the block to prevent the operating system from using the block, and allocate the pinned block to the virtual machine monitor *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ..."; Column 10: 37-40, "... the small code segment of Disco, currently 72KB, is replicated into all the memories of FLASH machine so that all instruction cache misses can be satisfied from the local node.").*

As per **Claim 57**, the rejection of **Claim 52** is incorporated; and Bugnion further discloses:

- wherein the software includes a virtual machine monitor that manages memory translation at runtime *(see Column 12: 6-15, "To virtualize physical memory, Disco adds a level of address translation and maintains physical-to-machine address mappings." and "Disco performs this physical-to-machine translation using the software-reloaded translation-lookaside buffer (TLB) of the MIPS processor.").*

As per **Claim 58**, the rejection of **Claim 52** is incorporated; and Bugnion further discloses:

- wherein the computer hardware further includes an I/O device; and wherein the software includes an operating system dual-mode driver that performs direct hardware control in a first mode and communicates with a corresponding device driver of a virtual machine monitor in a second mode; and wherein the dual-mode driver is set to the second mode during runtime interposition; and wherein I/O interrupts are redirected from interrupt handlers in the operating system to interrupt handlers in the virtual machine monitor *(see Column 11: 48-51, "Hardware interrupts are handled directly by the VMM through its own device drivers. The VMM posts an interrupt to the virtual machine when the operation that it has requested completes."; Column 14: 38-54, "We found it was much cleaner to simply add special device drivers into the operating system. Each Disco device defines a monitor call used by the device driver to pass all command arguments in a single trap." and "Disco's device drivers then interact directly with the*

physical device."; Column 17: 14-28, "Disco's monitor call interface reduces the complexity and overhead of accessing I/O devices." and "Fortunately, we designed the virtual machine monitor's internal device driver interface to simplify the integration of existing drivers written for commodity operating systems. Disco uses IRIX's original device drivers.").

As per **Claim 59**, the rejection of **Claim 52** is incorporated; and Bugnion further discloses:

- wherein the computer hardware further includes an I/O device; and wherein the operating system includes a dual-mode driver that performs direct hardware control in a first mode and communicates with a device driver of the virtual machine monitor in a second mode; and wherein the dual-mode driver is set to the second mode during interposition; and wherein I/O interrupts are redirected from interrupt handlers in the operating system to interrupt handlers in the virtual machine monitor *(see Column 11: 48-51, "Hardware interrupts are handled directly by the VMM through its own device drivers. The VMM posts an interrupt to the virtual machine when the operation that it has requested completes."; Column 14: 38-54, "We found it was much cleaner to simply add special device drivers into the operating system. Each Disco device defines a monitor call used by the device driver to pass all command arguments in a single trap." and "Disco's device drivers then interact directly with the physical device."; Column 17: 14-28, "Disco's monitor call interface reduces the complexity and overhead of accessing I/O devices." and "Fortunately, we designed the virtual machine monitor's internal device driver interface to simplify the integration of existing drivers written for commodity operating systems. Disco uses IRIX's original device drivers.").*

As per **Claim 60**, the rejection of **Claim 52** is incorporated; and Bugnion further discloses:

- wherein the computer hardware further includes an I/O device; and wherein the software causes I/O emulation of the I/O device to commence at runtime *(see Column 9: 63-67 through Column 10: 1-2, "Disco must intercept all communication to and from I/O devices to translate or emulate the operation.").*

18. **Claims 22, 44, and 65** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Bugnion** in view of **US 6,496,847 (hereinafter "Bugnion02")**.

As per **Claim 22**, the rejection of **Claim 21** is incorporated; however, Bugnion does not disclose:

- wherein devirtualizing the CPU further includes restoring privilege level of the operating system.

Bugnion02 discloses:

- wherein devirtualizing the CPU further includes restoring privilege level of the operating system *(see Column 13: 62-67, "... the HOS 340 is allowed, according to the invention, to manage resources such as the memory and devices, and to retain most of its normal functions and privileges, such as CPU scheduling.").*

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of Bugnion02 into the teaching of Bugnion to

include wherein devirtualizing the CPU further includes restoring privilege level of the operating system. The modification would be obvious because one of ordinary skill in the art would be motivated to resume normal operations of the operating system.

As per **Claim 44**, the rejection of **Claim 43** is incorporated; however, Bugnion does not disclose:

- wherein the devirtualizing means restores privilege level of the operating system.

Bugnion02 discloses:

- wherein the devirtualizing means restores privilege level of the operating system *(see Column 13: 62-67, "... the HOS 340 is allowed, according to the invention, to manage resources such as the memory and devices, and to retain most of its normal functions and privileges, such as CPU scheduling.").*

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of Bugnion02 into the teaching of Bugnion to include wherein the devirtualizing means restores privilege level of the operating system. The modification would be obvious because one of ordinary skill in the art would be motivated to resume normal operations of the operating system.

As per **Claim 65**, the rejection of **Claim 64** is incorporated; however, Bugnion does not disclose:

- wherein the software causes privilege level of the operating system to be restored.

Bugnion02 discloses:

- wherein the software causes privilege level of the operating system to be restored *(see Column 13: 62-67, "... the HOS 340 is allowed, according to the invention, to manage resources such as the memory and devices, and to retain most of its normal functions and privileges, such as CPU scheduling.")*.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of Bugnion02 into the teaching of Bugnion to include wherein the software causes privilege level of the operating system to be restored. The modification would be obvious because one of ordinary skill in the art would be motivated to resume normal operations of the operating system.

19. **Claims 24, 46-51, and 67-69** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Bugnion**.

As per **Claim 24**, the rejection of **Claim 21** is incorporated; however, Bugnion does not disclose:

- wherein devirtualizing the CPU further includes unloading the virtual machine monitor from the physical memory.

Official Notice is taken that it is old and well known within the computing art to release program data not in active use in a computer memory. Primary storage, such as RAM, is typically very fast and program data is constantly being swapped in and out for processing by the CPU. Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include wherein devirtualizing the CPU further includes unloading the

virtual machine monitor from the physical memory. The modification would be obvious because one of ordinary skill in the art would be motivated to free up memory space.

As per **Claim 46**, the rejection of **Claim 41** is incorporated; however, Bugnion does not disclose:

- wherein the devirtualizing means devirtualizes the memory at runtime.

Official Notice is taken that it is old and well known within the computing art to "devirtualize" memory at runtime. Once the virtual machine monitor stops running, all hardware components of the computer system are in effect "devirtualized." Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include wherein the devirtualizing means devirtualizes the memory at runtime. The modification would be obvious because one of ordinary skill in the art would be motivated to regain control of hardware components.

As per **Claim 47**, the rejection of **Claim 46** is incorporated; and Bugnion further discloses:

- wherein the virtualizing means allocates memory from an operating system to the virtualizing means; and wherein the devirtualizing means returns the allocated memory to the operating system *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ...").*

As per **Claim 48**, the rejection of **Claim 46** is incorporated; and Bugnion further discloses:

- wherein the devirtualizing means remaps physical memory and uses an operating system to manage address translation with respect to the devirtualized memory *(see Column 12: 6-15, "To virtualize physical memory, Disco adds a level of address translation and maintains physical-to-machine address mappings." and "Disco performs this physical-to-machine translation using the software-reloaded translation-lookaside buffer (TLB) of the MIPS processor.").*

As per **Claim 49**, the rejection of **Claim 41** is incorporated; and Bugnion further discloses:

- wherein the hardware includes an I/O device, wherein the virtualizing means virtualizes the I/O device; and wherein the devirtualizing means devirtualizes the I/O device at runtime *(see Column 9: 63-67 through Column 10: 1-13, "... requiring Disco to virtualize each I/O device." and "... these modifications can be made ... non-persistent so that they disappear with each reboot.").*

As per **Claim 50**, the rejection of **Claim 49** is incorporated; and Bugnion further discloses:

- wherein the memory is further encoded with an operating system including dual-mode drivers that perform direct hardware control in a first mode and communicate with device drivers of the virtualizing means in a second mode; and wherein the devirtualizing means sets the

dual-mode drivers to the first mode; and redirects I/O interrupts from handlers in the virtualizing means to handlers in the operating system *(see Column 11: 48-51, "Hardware interrupts are handled directly by the VMM through its own device drivers. The VMM posts an interrupt to the virtual machine when the operation that it has requested completes."; Column 14: 38-54, "We found it was much cleaner to simply add special device drivers into the operating system. Each Disco device defines a monitor call used by the device driver to pass all command arguments in a single trap." and "Disco's device drivers then interact directly with the physical device."; Column 17: 14-28, "Disco's monitor call interface reduces the complexity and overhead of accessing I/O devices." and "Fortunately, we designed the virtual machine monitor's internal device driver interface to simplify the integration of existing drivers written for commodity operating systems. Disco uses IRIX's original device drivers.")*.

As per **Claim 51**, the rejection of **Claim 49** is incorporated; and Bugnion further discloses:

- wherein the devirtualizing means ceases emulation of the I/O device at runtime *(see Column 10: 1-13, "... these modifications can be made ... non-persistent so that they disappear with each reboot.")*.

As per **Claim 67**, the rejection of **Claim 62** is incorporated; and Bugnion further discloses:

- wherein the virtualized hardware includes a memory *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ...")*.

However, Bugnion does not disclose:

- wherein the software causes a memory to be devirtualized at runtime.

Official Notice is taken that it is old and well known within the computing art to "devirtualize" memory at runtime. Once the virtual machine monitor stops running, all hardware components of the computer system are in effect "devirtualized." Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include wherein the software causes a memory to be devirtualized at runtime. The modification would be obvious because one of ordinary skill in the art would be motivated to regain control of hardware components.

As per **Claim 68**, the rejection of **Claim 67** is incorporated; and Bugnion further discloses:

- wherein if a part of a memory was allocated from an operating system to a virtual machine monitor prior to the runtime devirtualization, the software causes the allocated memory to be returned to the operating system as part of the runtime devirtualization *(see Column 8: 62-65, "The virtual machine monitor schedules the virtual resources (processor and memory) ...")*.

As per **Claim 69**, the rejection of **Claim 67** is incorporated; and Bugnion further discloses:

- wherein the software causes physical memory to be remapped and wherein the software allows an operating system to manage address translation with respect to the devirtualized memory *(see Column 12: 6-15, "To virtualize physical memory, Disco adds a level*

of address translation and maintains physical-to-machine address mappings." and "Disco performs this physical-to-machine translation using the software-reloaded translation-lookaside buffer (TLB) of the MIPS processor.").

Response to Arguments

20. Applicant's arguments with respect to Claims 1, 31, and 52 have been considered but are moot in view of the new ground(s) of rejection.

In the Remarks, Applicant argues:

a) As purportedly disclosing the subject matter of claim 19, the Office Action cited column 11, lines 17-19, of Bugnion. Column 11 of Bugnion states that an entity called "Disco" contains a simple scheduler that allows the virtual processors to be time-shared across the physical processors of the machine. Bugnion, 11:8-10. Bugnion also states that the scheduler cooperates with memory management to support affinity scheduling that increases data locality. Id., 11:10-12. The cited passage also notes that Disco assigns special semantics to the reduced power consumption mode of the MIPS processor, and that such reduced power consumption mode is used by the operating system whenever the system is idle. Id., 11:15-18. Column 11 of Bugnion also notes that Disco will deschedule the virtual CPU until the mode is cleared or an interrupt is posted. However, descheduling a virtual CPU appears to merely refer to the fact that a physical processor is not assigned to a particular virtual processor--this descheduling does not constitute devirtualizing computer hardware at runtime of a computer.

Applicant's argument presented above are consistent with a concession made by the U.S. Patent and Trademark Office in copending U.S. Serial No. 10/676,922, in which the Examiner in that application conceded that Bugnion "does not teach devirtualizing the I/O device at runtime." 6/4/2007 Office Action in U.S. Serial No. 10/676,922, page 8.

Examiner's response:

a) Examiner disagrees. Applicant's arguments are not persuasive for at least the following reasons:

First, with respect to the Applicant's assertion that descheduling does not constitute devirtualizing computer hardware at runtime of a computer, as previously pointed out in the Non-Final Rejection (mailed on 10/21/2008) and further clarified hereinafter, the Examiner respectfully submits that Bugnion clearly discloses "devirtualizing the virtualized computer hardware at runtime of a computer containing the virtualized computer hardware" *(see Column 9: 24-26, "Disco runs multiple independent virtual machines simultaneously on the same hardware by virtualizing all the resources of the machine."; Column 11: 8-20, "Disco contains a simple scheduler that allows the virtual processors to be time-shared across the physical processors of the machine." and "Disco will deschedule the virtual CPU until the mode is cleared or an interrupt is posted.")*. Note that Disco contains a scheduler that allows the virtual CPUs (*i.e.*, virtualization of the CPUs) to be shared across the physical CPUs. When appropriate, Disco will deschedule a virtual CPU. Thus, one of ordinary skill in the art would readily comprehend that when the virtual CPU is descheduled, it is no longer shared across the physical CPU and is, in effect, devirtualized.

Second, with respect to the Applicant's assertion that the Examiner in the copending Application No. 10/676,922 conceded that Bugnion "does not teach devirtualizing the I/O device at runtime," the Examiner respectfully submits that to the extend that the Applicant appears to rely on some preclusive effect of an Office action in copending Application No. 10/676,922 (Non-Final Rejection (mailed on 06/04/2007) at page 8), it is noted that non-mutual collateral estoppel cannot be used against the federal government. *United States v. Mendoza*, 464 U.S. 154 (1984).

Therefore, for at least the reasons set forth above, the rejections made under 35 U.S.C. § 102(b) with respect to Claims 19 and 41 are proper and therefore, maintained.

In the Remarks, Applicant argues:

b) Although Bugnion refers to device drivers, it is noted that Bugnion nowhere refers to a device driver that is able to operate in two different modes in the manner recited in claim 61. As purportedly disclosing the subject matter of claim 61, the Office Action cited the following passages of Bugnion: column 11, lines 48-51; column 14, lines 38-54; and column 17, lines 14-28. The cited column 11 passage of Bugnion refers to handling hardware interrupts directly by the VMM through its own device drivers. The cited column 14 passage of Bugnion refers to adding special device drivers into the operating system. The cited column 17 passage of Bugnion refers to Disco's monitor call interface reducing the complexity and overhead of accessing I/O devices. The cited column 17 passage also notes that the monitor call interface provides a view of an idealized device, and the implementation of drivers is straightforward.

However, none of the passages cited by the Office Action provide any hint of an I/O driver that is operable in two modes of operation in the manner recited in claim 61. Therefore, claim 61 is clearly not anticipated by Bugnion.

Examiner's response:

b) Examiner disagrees. With respect to the Applicant's assertion that Bugnion nowhere refers to a device driver that is able to operate in two different modes, as previously pointed out in the Non-Final Rejection (mailed on 10/21/2008) and further clarified hereinafter, the Examiner respectfully submits that Bugnion clearly discloses "computer memory encoded with an I/O driver having first and second modes of operation, the I/O driver operable in the first mode to interface directly between the operating system and the I/O device, the I/O driver operable in the second mode to interface between the operating system and a corresponding I/O driver of the virtual machine monitor" *(see Column 11: 48-51, "Hardware interrupts are handled directly by the VMM through its own device drivers. The VMM posts an interrupt to the virtual machine when the operation that it has requested completes."; Column 14: 38-54, "We found it was much cleaner to simply add special device drivers into the operating system. Each Disco device defines a monitor call used by the device driver to pass all command arguments in a single trap." and "Disco's device drivers then interact directly with the physical device."; Column 17: 14-28, "Disco's monitor call interface reduces the complexity and overhead of accessing I/O devices." and "Fortunately, we designed the virtual machine monitor's internal device driver interface to simplify the integration of existing drivers written for commodity operating systems. Disco uses IRIX's original device drivers.")*. Note that special device drivers

are added into the operating system to interact directly with the physical device (the I/O driver operable in the first mode to interface directly between the operating system and the I/O device) and the virtual machine monitor's internal device driver interfaces with the existing drivers of the operating system (the I/O driver operable in the second mode to interface between the operating system and a corresponding I/O driver of the virtual machine monitor).

Therefore, for at least the reason set forth above, the rejection made under 35 U.S.C. § 102(b) with respect to Claim 61 is proper and therefore, maintained.

Conclusion

21. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

22. Any inquiry concerning this communication or earlier communications from the Examiner should be directed to Qing Chen whose telephone number is 571-270-1071. The Examiner can normally be reached on Monday through Thursday from 7:30 AM to 4:00 PM. The Examiner can also be reached on alternate Fridays.

If attempts to reach the Examiner by telephone are unsuccessful, the Examiner's supervisor, Wei Zhen, can be reached on 571-272-3708. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the TC 2100 Group receptionist whose telephone number is 571-272-2100.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

/Q. C./

Examiner, Art Unit 2191

/Wei Y Zhen/

Supervisory Patent Examiner, Art Unit 2191